DETERMINATION OF THE WATER, SANITATION AND HYGIENE STATUS OF TWO PRIVATE SECONDARY SCHOOLS IN EGOR LOCAL GOVERNMENT AREA, BENIN CITY, EDO STATE

BY

ONOME ENDURANCE OGBA

LSC1605282

DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY

FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

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AN UNDERGRADUATE PROJECT WORK SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA; IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR AWARD OF BACHELOR OF SCIENCE (B.SC.) DEGREE IN ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY.

NOVEMBER, 2022.

CERTIFICATION

This is to certify that this research titled "Determination of the water, sanitation and hygiene status of two private secondary schools in Egor Local Government Area, Benin City, Edo State" was carried out by **"Onome Endurance Ogba"** and presented to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City; in partial fulfillment of the requirements for the award of Bachelor of Science (B.Sc.) in Environmental Management and Toxicology. It was conducted under suitable conditions, was carefully supervised and subsequently approved as having met the requirements for the award of Bachelor of Science degree in Environmental Management and Toxicology.

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Dr. E. E. Imarhiagbe   **Date**

Project Supervisor

………………………………………….   ………………………………..

Prof. A. A. Enuneku   **Date**

Head of Department

DECLARATION

I "Onome Endurance Ogba" declare that "Determination of the water, sanitation and hygiene status of two private secondary schools in Egor Local Government Area, Benin City, Edo State" is my own work and that all sources that I have used or quoted have been acknowledged by means of complete references and that this work has not been submitted before for any other degree at any other University.

Onome Endurance Ogba

…………………………

Date

DEDICATION

This work is dedicated to the Almighty Jehovah God who is and will forever be my source of courage and strength and my family, first my parents, Mr. and Mrs. O. M. Ogba, and my ever-supportive siblings for their care and understanding throughout this journey.

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I wish to express my profound gratitude to God Almighty for He has been doing great things in my life. Father, you are sufficient for me.

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ABSTRACT

The health and safety of children is a contributing factor to attendance in school and optimum academic performance. Having access to water, sanitation and hygiene factors prevents disease outbreaks among other benefits. This study was carried out to assess the WASH status of Faith Immaculate College and May and Steve Academy in Egor Local Government Area of Edo State, Nigeria. Water samples were collected from both schools and subjected to analysis of selected physicochemical and microbiological parameters. The WASH status of the schools was evaluated using data gathered through a questionnaire. From the results obtained, the physicochemical quality of the water in the schools were all within the permissible limits for pH, chloride, nitrite and biochemical oxygen demand as recommended by the World Health Organisation. Microbiological analysis revealed that the total heterotrophic bacterial counts (3.5×10^1 - 8.0×10^1cfu/ml) and total fungal counts (2.0×10^1 - 5.0×10^1cfu/ml) were within permissible limits. However, the total coliform counts (4 - 17MPN/100ml) far exceeded the limit Centres for Disease Control limit and indicates a potential health risk when consumed. The bacterial isolates from this study were *Escherichia coli, Klebsiella* sp., *Staphylococcus aureus* and *Bacillus* sp. while the fungal isolates are *Aspergillus niger, A. flavus, Mucor* sp. and *Penicillium citrinum.* The antimicrobial susceptibility pattern showed that only ciprofloxacin was effective in the treatment of all bacterial isolates. The assessment of WASH status revealed that there was water available at both schools and the sanitary facilities were adequate, although waste management at Faith Immaculate College was not satisfactory. Therefore, it is recommended that water treatment be carried out to improve its quality, while more efforts should be made to improve waste management practices especially in Faith Immaculate College.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Water, Sanitation and Hygiene (WASH) refers to the group of programs developed by the United Nations Children's Fund (UNICEF) aimed at battling disease situations which undermine community health (Hamlin, 2009). WASH covers problems related to water, sanitation and health and how these factors contribute to community diseases (Eneji *et al.,* 2015). Water, sanitation and hygiene are three fields which are separate but very much related with each being dependent on the others. In the absence of toilet facilities, sources of water in an area become contaminated; when clean water is unavailable, it becomes impossible to practice hygiene (Gomathi *et al.,* 2017).

Probably the most important landmark achievement in the development of WASH occurred when the General Assembly of the United Nations noted and accepted quality water and sanitation as basic human rights (Bennet *et al.,* 2018). It was reiterated that every human has rights to sufficient quantities of good quality water for personal and domestic uses. Such water must be safe, easily accessible in both distance and finance, and acceptable (Eneji *et al.,* 2015).

The provision of quality water in appropriate quantities to enable good sanitation and hygiene practices is one of the approached applied towards eradicating Neglected Tropical Diseases (NTDs) along with other diseases which are transmitted via the faecal-oral pathway (WHO and UNICEF, 2012). However, it is estimated that more than a third of the population of the earth lacked access to basic water, sanitation and hygiene facilities (Ngure *et al.,* 2014).

There are several diseases linked to poor WASH conditions; they include malaria, hookworm diseases, trichuriasis, ascariasis, schistosomiasis, trachoma and Japanese encephalitis

(Fewtrell *et al.,* 2005). Poor WASH conditions also contribute to transmission of diseases through the faecal-oral pathway such as diarrhoea, enteric infections, hepatitis and helminthes (Gomathi *et al.,* 2017). It is on record that poor WASH facilities and conditions are responsible for around 7% of the world's total disease burden while contributing to about 19% of morbidity and mortality in children around the world (Bartram and Cairncross, 2010).

Improving access to facilities of water, sanitation and hygiene brings health benefits to people living in the area while improving the economy as a result of decreases in the adverse effects of ill health on labour, productivity and income levels of workers (Inah *et al.,* 2020). Some measures aimed at improving the state of WASH in communities include improving access to clean and safe drinking water, building latrines and educating the people on hygienic practices (Hamlin, 2009), treatment of drinking water, discouraging open defecation and vaccination against diseases (Bennet *et al.,* 2018).

It is against this background that this study attempts to examine the water, sanitation and hygiene conditions and practices in selected private secondary schools in Ovia North-East LGA, Edo State in Nigeria.

1.2 Aim and Objectives

The aim of this study was to determine the water, sanitation and hygiene conditions of selected schools in Ovia North-East LGA, Edo State, using specific parameters.

The objectives of the study were to:

1. Assess the sanitation and hygiene conditions of the selected schools.
2. Determine some selected physicochemical qualities of water samples collected from the schools.
3. Enumerate and isolate the bacterial and fungal population of the water samples.

CHAPTER TWO

LITERATURE REVIEW

2.1 Water, Sanitation and Hygiene (WASH)

Safe drinking water, sanitation and hygiene (WASH) are key determinants of human health and well-being (Eneji *et al.,* 2015). In addition to being essential for health living, safe water and sanitation are important contributors to the livelihood of the people, attendance in schools and dignity, and consequently, the development of resilient communities within healthy ecosystems (UNICEF, 2017). The consumption of contaminated drinking water leads to illnesses among which are cholera and diarrhoea, while untreated faecal matter causes contamination of water sources, both surface and ground water, which are used for various purposes including domestic and agricultural (Uddin *et al.,* 2018).

Sufficient access to WASH has been identified as a crucial player in averting a wide spectrum of non-communicable diseases, such as schistosomiasis, soil helminths and trachoma. Diarrhoeal diseases which result from deficiencies in WASH systems were slashed in half during the period of the Millennium Development Goals (MDGs) (1990 - 2015). This was brought about by the major improvements in the management and sterilisation of water which occurred during the period (WHO, 2019).

It has been shown that health levels have been enhanced through lowering of deaths resulting from diarrhoeal diseases by improving the service levels for securely-controlled drinking water and sanitation such as regulation of piped water or the connection between sewers and wastewater treatment plants (UNICEF, 2017). In 2010, the United Nations General Assembly declared that safe and clean drinking water and sanitation are human rights and requested that there be international assistance mechanisms to enable governments provide safe, clean, accessible and affordable drinking water and sanitation. By this declaration, it is recognised that every individual has a right to sufficient, continuous, safe, acceptable, physically accessible, and affordable water for personal and domestic use (UNICEF, 2017; WHO, 2019).

Water, Sanitation and Hygiene (WASH) serves as a health multiplier and United Nations Children's Fund has stated that there are several direct implications associated with poor access to WASH facilities. Among these are the increase in occurrences of diseases and infections, especially diarrhoea, which is implicated in malnutrition and the reduction of disease immunity, and enabling the spread of other diseases and infections. According to a 2016 World Bank report, an estimated 36.8% and 37% of children in Nigeria are stunted and underweight, respectively, and more than 733,000 deaths which occur annually are a primary result of the increased incidences of diseases.

Pruss *et al.* (2002) assessed the worldwide illness burden from water, sanitation, and hygiene, based on a variety of disease outcomes, primarily diarrheal diseases. The disability-adjusted life year (DALY) integrates the burdens of death and disability into a single index, allowing comparisons of the burdens of water, sanitation, and hygiene to other risk factors or diseases. For 14 geographical regions, the world's population was divided into typical exposure situations. Then these scenarios were matched to relative risk data gathered primarily from intervention studies. The calculations suggest that diarrheal diseases, schistosomiasis, trachoma, ascariasis, trichuriasis, and other water, sanitation, and hygiene-related disorders account for 4.0 percent of all fatalities and 5.7 percent of the overall disease burden (in DALYs) occurring globally.

He *et al*. (2018) assessed Childhood Diseases in Relation to Improved Water, Sanitation, and Hygiene (WASH) among Nigerian Children. Logistic regression was used to examine the link between diarrhoea, fever, and chronic cough and sanitation and hygiene techniques. The prevalence of diarrhoea, fever, and cough was found to be, respectively, high, medium, and low. Children in households lacking all three types of facilities had 1.32, 1.24 and 1.43 times higher odds of suffering from diarrhoea, fever, and cough, respectively, according to the regression analysis. According to the findings, poor WASH conditions are a major contributor to acute respiratory infections (ARIs) and diarrheal morbidity among Nigerian children. In view of these findings, it is suggested that programs aimed at reducing childhood morbidity and death due to prevalent infectious diseases make use of equitable WASH measures.

Orimoloye *et al*. (2015) carried out a study in Ibadan were the water sanitation and hygiene practices of randomly selected households in the Ibadan North Local Government Area of Oyo State, Nigeria was analyzed. A total of 450 people were asked to fill out questionnaires. According to the survey results, 56.4% of respondents treated their water, while 43.6% did not. 28% of those who treated their water boiled it, 20.1% filtered it with alum, and 33.5% used chlorine. 67.3% of families used a pour-flush toilet, 16% used a vented improved pit latrine, and 1.8% defecated in the bush. 37.3% washed their hands after using the restroom, and 43.5% washed their hands after eating, according to the findings. 25.8% washed their hands with water only, 28% washed their hands with medicated soap and water. 31.8% of the respondents reported a history of sickness from water usage while 68.2% did not. The symptoms experienced include stomach pain 28.7%, fever 28.7%, stooling 30.8% and vomiting 11.9%. Sensitization of the populace toward proper disposal of household waste, promotion of good hygiene practices and treatment of drinking water was recommended.

The World Health Organisation in 2020 reported that nearly 73% of the enteric illness burden for Nigerian children who are below five (5) years old is a result of poor WASH. This leads to a situation where the presence of faecal germs and waterborne infections in communities cannot be counterbalanced by increased food abundance unless the state of WASH is improved (WHO, 2020).

The World Bank in 2019, reported that in recent years there has been an increase in the efforts of the Nigerian Government working in conjunction with the International Monetary Fund towards bringing about improvements in access to WASH services, in a bid to allow the WASH sector in Nigeria to matchup to that of other countries within the West African region. To further this goal, the Nigerian government, in 2018, declared a State of Emergency together with the launching of the National Action Plan (NAP) aimed at ensuring that by 2030, there would be national accessibility to WASH services in line with the objectives outlined by the Sustainable Development Goals (SDGs). The strategy is expected to take 13 years to implement in three phases which are emergency, recovery and revitalisation. Other strategies incorporated in this plan include the Clean Nigeria programme, Use the Toilet Campaigns (for the elimination of open defaecation on Nigeria by the year 2025 and the Sustainable Urban and Rural Water Supply, Sanitation, And Hygiene (SURWASH) program which is designed to support in the enactment and implementation of policy reforms where necessary and to strengthen the institutional capacity to allow for sustainable, effective service delivery (World Bank, 2019).

2.1.1 Sanitation and health

It is estimated that annually, in middle- and low-income countries as many as 827,000 lives are lost due to lack of or insufficient WASH, which accounts for about 60% of all diarrhoeal-related deaths worldwide (Gomathi *et al.,* 2017). According to the WHO, poor sanitation is the primary cause of 432,000 deaths each year with 297,000 of these being children below the age of five. The common practice of open defaecation is a factor that keeps the vicious cycle of poverty and diseases going. It is worthy of note that countries having the highest open defaecation rates also have the largest number of child mortality cases for children under five, in addition to the worst levels of poverty and starvation (WHO, 2019).

2.1.2 Benefits of improving sanitation

There are numerous benefits to be accrued form improvement in sanitation. Among these are; reduction in the proliferation of trachoma, schistosomiasis and intestinal worms, which are often relegated to the background although they are the causes of the suffering of millions of people; decrements in the severity and impacts associated with malnutrition; increase in the levels of dignity and safety of the people especially in women and girls; improvement of attendance in school; and the potential for water, nutrients and renewable energy recovery (Eneji *et al.,* 2015). According to the World Health Organisation, for every dollar spent on sanitation, a return of $5.50 is realised in the areas of fewer premature deaths, increments in productivity at work and lesser expenses for health (WHO, 2012).

2.1.3 Drinking Water

As at 2017, about 71 percent of the entire population of the world (approximately 5.3 billion people) consumed water from a drinking water service that was safely managed, i.e. it was on-site, readily available and devoid of contamination. Basic drinking water service would encompass improved drinking water from a source which takes a maximum of 30 minutes for a round trip to collect water. As at 2019, it was estimated that 785 million people worldwide, which included 144 million who relied on surface water lacked access to basic drinking water services (Patel, 2019). At the very least, around 2 billion people worldwide consume water which has been tainted by faecal matter Yearly, contaminated drinking water is identified as the cause of an estimated 485,000 fatalities due to diarrhoeal diseases. It is projected that, by 2025, up to half of the population of the Earth will inhabit areas which will be water-stressed. In countries which are less-developed, situation reports have shown that water service is lacking in 22% of healthcare facilities, while 22% and 21% respectively, lack waste management services and sanitation services (WHO, 2019).

The importance of safe and readily available water in public health cannot be overemphasised as it is used for domestic and recreational purposes, and food production, among other uses. When there are improvements in the water supply and sanitation, in addition to improved management of water resources, the outcome of these is a boost in the economic growth of the country and a direct contribution to reduction of poverty (Akter *et al.,* 2016).

2.1.4 Water and health

The use of contaminated water and poor sanitation have been associated with the occurrence of several diseases such as diarrhoea, cholera, dysentery, polio, hepatitis A and typhoid. This is because the lack of, insufficiency or poor management of water and sanitation services/facilities predisposes individuals to avoidable health risks. This is never more true than in healthcare facilities where the danger of patients and employees contracting infections and diseases are multiplied when there is a shortage of water, sanitation and hygiene facilities. Globally, it has been discovered that during a spell in the hospital, about 15% of patients contract a new infection and in low-income countries, the proportion of these is higher (Gomathi *et al.,* 2017).

Every year diarrhoea due to inadequate drinking water, hand hygiene and sanitation is identified as the cause of an estimated 829,000 deaths. This is appalling due to the fact that diarrhoea is an entirely preventable disease and removing its risk factors would protect the lives of as many as 297,000 children below the age of five years, annually. Water scarcity leads individuals to the lessen the priority level of handwashing and increases the risk of the occurrence of diarrhoea and other illnesses (WHO, 2019).

Of the aliments which are associated with contaminated water and food, diarrhoea is the most well-known, however, other risks exist. It is recorded that, in 2017, approximately 220 million people worldwide required preventive treatment for schistosomiasis which is caused by a parasitic worm present in contaminated water (Uddin *et al.,* 2018). Insects which live or breed in water serve as carriers and spread various diseases including dengue fever in many parts of the world. These disease vectors often breed in clean rather than dirty waters and open containers used for domestic drinking water storage often serve as good breeding grounds for these vectors. A simple measure to counter this is to cover these containers and this has proven effective in the prevention of vector breeding and faecal contamination of water in homes (Bennett *et al.,* 2018).

2.1.5 Economic and social effects

When water comes from more accessible and improved sources, they expend less effort and spend less time collecting it and this increases their productivity in other areas. Having a water source which is close-by improves safety as the travel distance for water collection or risks associated with water collection are minimised. Better water supply contributes to the increased disease resistance and the reduction of the medical bills of the people. Consequently, this contributes to them continuing being economically active. For children who are at greater risk of contracting water-related diseases, having access to improved water sources accrues to better health states which is reflected in better school attendances and good effects on their lives in the long-term (Uddin *et al*., 2018).

There is a plethora of challenges facing water supply systems around the world. Some of these are urbanisation, demographic shifts, increase in human population, increasing water shortages and climate change. It is projected that by 2025, areas which are water-stressed will be home to about half of the world's population. One of the emerging methods to alleviate these problems is the reuse of wastewater for recovery of water, energy and minerals. Wastewater is applied in many poor countries for irrigation of farmlands and it accounts for about 7% of all irrigated land. There are health risks associated with the improper implementation of this method, however, when done properly, wastewater management provides a variety of benefits, one of which is increase in food output (WHO, 2019).

There will be continual changes in the sources of water available for drinking and irrigation as reliance on groundwater and other alternative sources, e.g. wastewater, increases. With the recent trends in climate change, there will be higher unpredictability in rainwater harvesting. There will need to be improvements in the management of water resources to ensure long-term water provision and quality.

2.2 The State of Water Supply and Sanitation in Nigeria

The lack of access to quality water and sanitation services has long been known to be a contributing factor to the high death and morbidity rates among Nigerian children under five years of age. More than 70,000 children under five years old die due to waterborne diseases annually, and the poor state of sanitation and consumption of contaminated drinking water increases the vulnerability of many more children (Goldface, 2021). As much as 73% of the enteric and diarrhoeal disease burden has been linked to lack of or insufficient access to good water, sanitation and hygiene, and the majority of this number is made of children of the very poor. Children who have frequent episodes of illnesses related to poor WASH are often absent from school and show evidence of malnutrition. In short, only 26.5% of the Nigerian population has access to acceptable levels of drinking water and sanitation services, while up to 23.5% of the general population practices open defaecation (UNICEF, 2015).

In Nigeria, the three levels of government i.e. the federal, state and local governments share the responsibility for water supply (Ajisegiri, 2011). Water resources management is carried out by the federal government; urban water supply is the primary responsibility of the state governments; and the local governments, acting together with the local communities, carry out responsibilities relating to rural water supply. However, there are no clear definitions of the responsibilities for sanitation. In many parts of the country, the quality of water supply service and the recovery of costs are very low; added to that, the water tariffs are quite low and, more often than not, many users do not pay their water bills. As such, the providers of such services have to rely on the subsidies which are provided occasionally to cover their operating expenditure (Inah *et al.,* 2020).

Nigeria lacks a centralised sewerage system except in the large cities such as Abuja and in parts of Lagos; the result of this is that septic tanks are the most common method of providing adequate sanitation (USAID, 2007). As at 2006, a study showed that only 1% of the residential house in Lagos state were connected to a sewer system. There are four wastewater treatment plants in the state which were all renovated in 2010. As at 2011, the state made plans to develop ten (10) new mega plants for wastewater treatment over five years, with support received from private investors. However, these plants are yet to be completed. Different agencies have different definitions and metrics for indicators and methodologies leading to contradictory statistics on the state of access to water and sanitation. Also, in the WASH sector in Nigeria, there are little to no provisions for monitoring (Etim, 2017).

In September of 2010, a study conducted by Amnesty International provided proof that Shell oil corporation and the government of Rivers state do not make enough efforts geared towards the provision of safe water supply to Ogale town, which is just a short distance away from the state capital. Because of this, residents of the town have to either drink water collected from wells which have been contaminated by benzene or purchase drinking water at exorbitant prices. The World Bank stated that facilities for water production in Nigeria do not operate at their full capacity due to problems such as break down of equipment, and lack of fuel or electricity to pump water. The inconsistencies of power supply in Nigeria causes an increase in the operating costs of water agencies as they rely on diesel generators or develop power plants of their own, as some do. Additionally, there is poor maintenance of piping systems and equipment, resulting to irregular water supply and increases in the non-revenue water (World Bank, 2010).

By the year 2000, up to 80% of water systems owned and controlled by the Nigerian government located in small town were not in operation (NSSIS, 2010). To enable short-term increases in the functionality of water points, investments and capacity building for communities are essential. An example of this can be seen in focus communities within Kwara state which were supported by UNICEF, where the functionality of water points increased to 98% from 53%, while that of Kebbi state has grown to 88% from 12%. There is a lack of clarity on the ability of these facilities to continually function to their full capacities in the long-term, especially after the end of the international interventions (Ndidi and Amanambu, 2014).

2.3 Measurement of water quality (Water quality index)

The quality of water determines its suitability and acceptability for the various uses for which it is required. The quality of water is dictated by its composition and this, in turn, is influenced by a combination of both natural and anthropogenic processes. Water quality is calculated using a suit of water parameters which are classified into physical, chemical and microbiological parameters, and if the values for these parameters exceed permissible limits, human health may be placed in jeopardy (WHO, 2012). The Centres for Disease Control (CDC) and World Health Organisation (WHO) have set defined exposure guidelines and acceptable limits for various chemical pollutants which may be present in water. There exists a common misconception that water which is clean is of high quality, and this implies that there is a knowledge gap as regards the presence of contaminants in water (Akter *et al.,* 2016). Ensuring the availability and sustainable management of water of good quality is one of the goals of the Sustainable Development Goals (SDGs). This has revealed a challenge which policy makers and WASH practitioners face especially with various other problems also in play such as poverty, urbanisation, changes in climate and increasing population (WHO, 2019). Managing the quality of water involves collecting and analysing large datasets of water quality parameters which are often problematic to assess and synthesize. To handle this, several tools have been developed to assess data on water quality and the Water Quality Index (WQI) is one of these (Akter *et al.,* 2016).

Water Quality Index models are built on the aggregation functions which allow for the analysis of water quality datasets which vary temporally and spatially to yield a single value which serves as an indicator of the quality of the water being considered. Water management companies and water supply agencies find water quality indices to be effective and easy to apply for the conversion of complex datasets of water quality parameter values into single value measures of water quality that are much easier for the people to understand and use (Tyagi *et al.,* 2013). The Water Quality Index method is viewed as the technique for assessing the quality of water with the highest accuracy. It involves the use of a mathematical equation which takes into account a set of water quality parameters to grade the quality of a given sample of water and evaluate its suitability for desired uses. The Water Quality Index was initially developed in 1965 by Horton for the measurement of water quality using the ten (10) most commonly-used water quality parameters. Over time, various experts made modifications to the method to create other water quality indices. These indices employ a variety water quality parameters and different types. The weights which a parameter carries in an index depends on the standards for that parameter and the weight assigned to a parameter shows how significant it is and determines how much it influences the index (Ochuko *et al*., 2014).

While it is dependent on a variety of factors, the water quality index produces a single value which is a measure of the overall quality of water in a place at a given time. Using the WQI opens up the possibility of comparing data collected from samples taken from various locations (Akter *et al.,* 2016). One major advantage of the WQI is that it simplifies a complex dataset into an easily understandable and usable format. The single value obtained provides important water quality information which can be easily understood and interpreted by everyone. The water quality classification system which is a feature of every water quality index serves as an indicator of the suitability of water for various uses (Sutadian *et al.,* 2016).

Making use of water quality index takes place in four stages. The first is the selection of the water quality parameters of interest. Secondly, the values obtained for each parameter are read and the values for each are converted into a single-value sub-index having no dimensions. This is then followed by the determination of the weighting factor for each of the parameters. Finally, the overall single water quality index value is obtained by the aggregation formula involving the various weighting factors and sub-indices for the parameters selected (Akter *et al.,* 2016). There have been a good number of WQI models which have been developed with structural variations, differences in selected parameters and weightings for each parameter, and varied methods for sub-index analysis and aggregation (Sun *et al*., 2016). The majority of components for WQI models are developed on the basis of reviews of experts and local guidelines resulting in regional specificity of many of these models (Sutadian *et al.,* 2016). Some researchers have pointed out the uncertainties associated with WQI models; and while in any mathematical model, there are elements of uncertainly, the four stages of the WQI calculation have the capacity to contribute to uncertainties in the model (Lowe *et al.,* 2017).

2.4 Health conditions tied to WASH

Good state of human health is dependent on the state of WASH. In spite of this, safe drinking water is not accessible for over 884 million people around the world (CDC, 2020). Unsafe water sanitation and hygiene services have been linked to both infectious and non-communicable diseases due to exposure to toxic components in drinking water, as well as general adverse effects on human well-being (WHO/FAO, 2020). Up to 2.4 billion people lack access to basic sanitation services and many resort to open defaecation, thereby jeopardising the safety and usability of water for drinking and other purposes. Use of unsafe water and lack of sanitation are often identified as the cause of many diarrhoeal diseases. Cholera and typhoid are two of the most common illnesses which are spread in situations of poor hygiene. There have also been linkages established between poor WASH conditions and the occurrence of emerging disease challenges e.g. widespread resistance of typhoid fever to treatment (CDC, 2020). The pathogens which are responsible for causing these diseases are transmitted during the use of contaminated water for purposes such as drinking, washing, food preparation, etc. In the rural areas of many developing countries, water treatment plants are not available to alleviate this problem. Also, in some places, water availability levels are so low that much money is spent on purchasing water that there is little left to obtain water purifiers and other mechanisms for water treatment (Patel, 2019).

2.4.1 Diarrhoea

Among the water-borne diseases, diarrhoea is the most frequently occurring and it commonly affects children below the age of five years. Symptoms of the condition include pale complexion, dehydration, dizziness and loss of consciousness in extreme cases. Diarrhoea often lasts for a short time (about a week) but if it is not treated, it could lead to the death of the affected individual (Patel, 2019).

Diarrhoea is also occasioned by and is a symptom many other water-borne diseases and is evidenced by a dramatic loss of body fluids resulting in severe dehydration and subsequent mortality. For children under five years of age, diarrhoea has been ranked the fifth most common cause of death. Experiencing diarrhoea on a frequent basis can cause stunting of the physical growth and cognitive development of children while increasing their susceptibility to other infectious conditions. It is estimated that up to 88% of deaths related to diarrhoea are the result of consumption and use of contaminated water, poor hygiene and poor sanitation practices (CDC, 2020).

2.4.2 Cholera

Cholera is classified as a diarrhoeal condition and its causative organism is the toxigenic bacterium *Vibrio cholerae* serogroup O1 or O139 which infects the intestines of the affected individual. On a yearly basis, there are approximately 2.9million cases and 95,000 deaths due to cholera worldwide. In most cases, cholera is mild/asymptomatic, however, when left unattended it may become a serious illness. There are several symptoms of cholera which include vomiting, watery diarrhoea and leg cramps for one in every ten (10) persons affected by cholera. This occurs because the rapid loss of body fluids results to dehydration and shock in affected individuals and, when left untreated, is followed by death within a few hours (CDC, 2021).

The causative organism for cholera is often present in food or water which have been contaminated with faecal matter containing the bacteria. In places where conditions of poor sanitation, inadequate hygiene and insufficient water treatment are prevalent, the likelihood of cholera occurring and spreading is very high (Patel, 2019). Cholera-causing bacteria are also present in coastal waterways and rivers containing brackish water and this has been shown in the contraction of cholera through the handling and consumption of raw shellfish.

In the USA, there have been rare cases of cholera occurring after the consumption of raw or undercooked shellfish captured in the Gulf of Mexico (CDC, 2021).

Normally, cholera is contracted by eating contaminated food or drinking contaminated water, however, when there is a cholera epidemic, it is often spread by faecal matter from an infected individual which then contaminates the food and water in the vicinity. Poor sewage management and drinking water treatment are the major conditions that give room for the disease to spread rapidly. The likelihood of a direct transmission of the bacteria from person to person is very unlikely, as such, having casual contact with an infected individual does not count as a risk factor for cholera. People at the highest risk of contracting cholera are those who live where conditions of poor hygiene, sanitation and unsafe drinking water prevail (WHO, 2019).

2.4.3 Typhoid

Typhoid is an illness that is spread through contaminated water and caused by the bacteria *Salmonella typhi.* Common symptoms of typhoid among patients are headaches, loss of weight, constipation, nausea, appetite loss and recurrent bouts of fever. Prompt medical attention is a requirement for the cure of typhoid in a patient and for the prevention of further spread of the disease (Patel, 2019). The most common means through which the disease is spread are the urine and faecal matter of infected persons.

Salmonella typhi bacteria causes typhoid illness, which is spread by contaminated water. Frequent episodes of fever, loss of appetite, nausea, headache, constipation, and weight loss are common among the patients. To cure typhoid in the patient and prevent the spread of this deadly disease, prompt medical attention is required (Patel, 2019). Infected persons spread their germs via their feces and pee. People become infected after eating or drinking food or beverages touched by an infected person, or after drinking water tainted by sewage carrying the bacteria (Lenttech, 2005).

The bacteria proliferate and travel from the intestines to the bloodstream once they enter a person's body. Typhoid symptoms emerge 10 to 14 days after infection; they can be mild or severe and include high fever, rose-colored spots on the abdomen and chest, diarrhoea or constipation, and enlargement of the spleen and liver. In untreated patients, complications may be numerous, affecting practically every body system, and can even include perforation of the intestine with haemorrhage. Complications account for the mortality rate of 7% to 14%, (Lenttech, 2005).

2.4 4 Dysentery

Dysentery is a waterborne intestinal illness marked by severe diarrhea and blood or mucus in the stool. Dysentery is a good reason to wash your hands frequently because the disease is spread primarily through improper hygiene. Bacteria, viruses, and parasites in tainted food and water, as well as humans who come into touch with feces, can cause it. If a person with dysentery does not replace fluids soon enough, their life may be jeopardized. Stomach cramps and soreness, diarrhea, fever, nausea, vomiting, and dehydration are some of the symptoms (Lifewater, 2018).

2.4.5 Giardia

This disease is spread by contaminated water, which can be found in ponds and streams, but also in a town's water supply, swimming pools, and other places. A parasite causes the infection, which usually goes away after a few weeks. Those who have been exposed, on the other hand, may endure stomach difficulties for years to come. Abdominal pain, cramps and bloating, diarrhea, nausea, and weight loss are some of the symptoms (Lifewater, 2018).

2.4.6. Hepatitis A

Hepatitis A is a liver infection brought on by the hepatitis A virus (HAV). The virus is spread largely when an uninfected (and unvaccinated) person consumes food or water contaminated with an infected person's feces. The disease is linked to contaminated water or food, poor sanitation, personal hygiene, and oral-anal sex (WHO, 2022).

Hepatitis A, unlike hepatitis B and C, does not cause chronic liver disease, but it can induce debilitating symptoms and, in some cases, fulminant hepatitis (acute liver failure), which can be fatal. According to the World Health Organization, 7134 people died from hepatitis A in 2016. (accounting for 0.5 percent of the mortality due to viral hepatitis).

Hepatitis A occurs intermittently and in epidemics all throughout the world, with a cyclic recurrence pattern. Epidemics caused by tainted food or water, such as the one that killed 300,000 people in Shanghai in 1988, can be devastating (GHR, 2017). They can also be long-lasting, with person-to-person transmission affecting communities for months. Hepatitis A viruses survive in the environment and can withstand the inactivation or control of bacterial pathogens used in food production (WHO, 2022).

The hepatitis A virus is transmitted primarily by the faecal-oral route; that is when an uninfected person ingests food or water that has been contaminated with the faeces of an infected person. In families, this may happen though dirty hands when an infected person prepares food for family members. Waterborne outbreaks, though infrequent, are usually associated with sewage-contaminated or inadequately treated water, (UNICEF, 2017)

2.5 Consequences of poor WASH facilities

Lack of access to these fundamental life-saving services has an impact on almost every area of human development, disproportionately harming the life chances of women and girls. Goal 6 of the United Nations Sustainable Development Goals (SDGs) is to ensure that everyone has access to safe, affordable drinking water, sanitation, and hygiene. Millions of people in low- and middle-income nations, such as Nigeria, lack access to clean water and sanitation. According to the Water, Sanitation, and Hygiene National Outcome Routine Mapping, around 55 million Nigerians still lack access to safe drinking water, 110 million lack adequate toilets, and over 47 million defecate in the open (Inah *et al.,* 2020).

The government of Nigeria declared a state of emergency in the water, sanitation, and hygiene (WASH) sector in 2018 (World Bank, 2021). In 2019, around 60 million Nigerians were living without access to basic drinking water due to a combination of inadequate infrastructure, a lack of essential human resources, low investment, and a deficient enabling regulatory environment, among other difficulties. 80 million people lacked adequate sanitation, and 167 million had access to even basic handwashing facilities (World Bank, 2021)

In rural areas, 39% of households do not have access to basic water, just half have access to improved sanitation, and almost a third (29%) practice open defecation, a ratio that has barely changed since 1990. The lack of proper WASH services disproportionately affects women and girls. They suffer the brunt of long-distance water collection, which has been linked to lower well-being, school attendance, and a higher risk of gender-based violence (GBV). WASH access can affect years of schooling by reducing the amount of time children spend collecting water to get to school, reducing the prevalence of disease that can keep them out of school, and contributing to a safe and healthy learning environment at school (Eneji *et al.,* 2015).

The effects of poor sanitation are also costing Nigeria economically. The Nigerian Water and Sanitation Program estimates that poor sanitation costs the country at least three billion U.S. dollars each year in lost productivity and health care expenditures (World Bank, 2021). Poor water supply and sanitation cost the Nigerian economy roughly 1.3 percent of GDP per year, or NGN1.9 trillion, according to UNICEF (UNICEF, 2017). These losses are represented in lost productivity due to water and sanitation related diseases, time spent obtaining water and sanitation services, needless government and household expenses to manage the diseases, and human capacity lost due to hunger and mortality. Furthermore, insufficient access to water sources has been blamed for some of the disputes in the North-Central region, (WaterAid, 2018).

2.6 Measures to improve WASH in Nigeria

Government investment needs for achieving SDG 6 by 2030 are anticipated to be 1.30 percent of GDP per year, or $5.3 billion (NGN1.9 trillion). This is in contrast to current government and donor investment of only $393 million (in 2018). The government must enhance budgetary allocations for water, sanitation, and hygiene, as well as guarantee that the funds granted are used efficiently (WaterAid, 2018)

To advance the achievement of the development goals, strong governance and high-level political backing are required. SDG 6 is a formidable challenge that can only be met by ensuring appropriate governance and coordination structures at all levels of government; improving access to and transparency of financial data; addressing problems with operations and maintenance (which currently jeopardize service sustainability); strengthening the enabling environment for the public and private sectors; and increasing civil society engagement. Furthermore, in order to drive the necessary transformation, flexible solutions to the sector's difficulties must be identified (Ochuko *et al*., 2014)

In recent years however, the Government of Nigeria has strengthened its commitment towards improving access to WASH services, spurred on by the need for Nigeria’s WASH sector to catch up with its regional counterparts. This led to the Government declaring a State of Emergency in 2018 and launching the National Action Plan (NAP) aimed at ensuring universal access to sustainable and safely managed WASH services by 2030, commensurate with the SDGs (World Bank, 2019). This is a 13-year strategy prioritizing actions within three phases: Emergency Plan, Recovery Plan, and Revitalization Strategy and also the Clean Nigeria; Use the Toilet Campaign which aims to have Nigeria free of open defecation by 2025.

The World Bank Group has launched the Nigeria Sustainable Urban and Rural Water Supply, Sanitation, And Hygiene (SURWASH) Program to assist the Nigerian government with activities aimed at enacting necessary policy reforms and strengthening institutional capacity for effective and sustainable service delivery (World bank, 2021)

It will back an integrated package of investments to promote access to and use of WASH services in urban, rural, and small-town settings. This involves the construction of priority infrastructure to improve water supply service delivery and WASH infrastructure in institutions (such as schools and hospitals) as well as public spaces such as marketplaces and parking lots.

The SURWASH Program is projected to provide 6 million Nigerians with basic drinking water services, support 1.4 million in accessing improved sanitation services, develop improved WASH services in 2,000 schools and Health Care Facilities, and assist 500 communities in achieving ODF status (World Bank, 2021).

The SURWASH Program is performance-driven, and all Nigerian states are eligible to participate based on their commitment to certain sector improvements. The Program will assist the Government of Nigeria in enacting required policy reforms and incentivizing state and local governments, service providers, Technical Assistance providers, and community-based organizations (CBOs) to offer effective and sustainable services in the sector. It will back a package of initiatives that will boost access to and usage of WASH services in cities, small towns, and rural regions. The initiative will specifically promote the building of infrastructure to improve water supply service delivery, sanitation, and hygiene in institutions (such as schools and healthcare facilities) as well as public spaces such as markets, parking lots, and other locations.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY AREA

This present study was undertaken in Benin City, the capital of Edo State which is situated in the southern part of Nigeria. The geographical location of the city is at latitudes 6^o 11' and 6^o 29'N, and longitudes 5^o 33' and 5^o 47'E. It is located in the humid tropical rainforest belt of Nigeria. The schools which were assessed during the study are Faith Immaculate Academy (6°18'53.4" N, 5°36'72.44" S) and May and Steve College (6°25'54.00" N, 5°36'27.54" S) located in Egor Local Government area. Figure 3.1 shows the sampling locations for this study.

3.2 SAMPLE COLLECTION

Water samples were collected from two points at the studied schools. These points were designated F1 and F2 (Faith Immaculate), and M1 and M2 (May and Steve Academy). Sampling bottles were properly washed with detergents and autoclaved before being used for sample collection. The caps of the borehole taps were first cleaned with cotton wool and ethanol to ensure that samples were not externally contaminated. The taps were opened and samples were collected immediately (Bennett *et al.,* 2018). The samples were then stored under ice at 4°C and taken to the laboratory for physicochemical and microbiological analysis immediately.

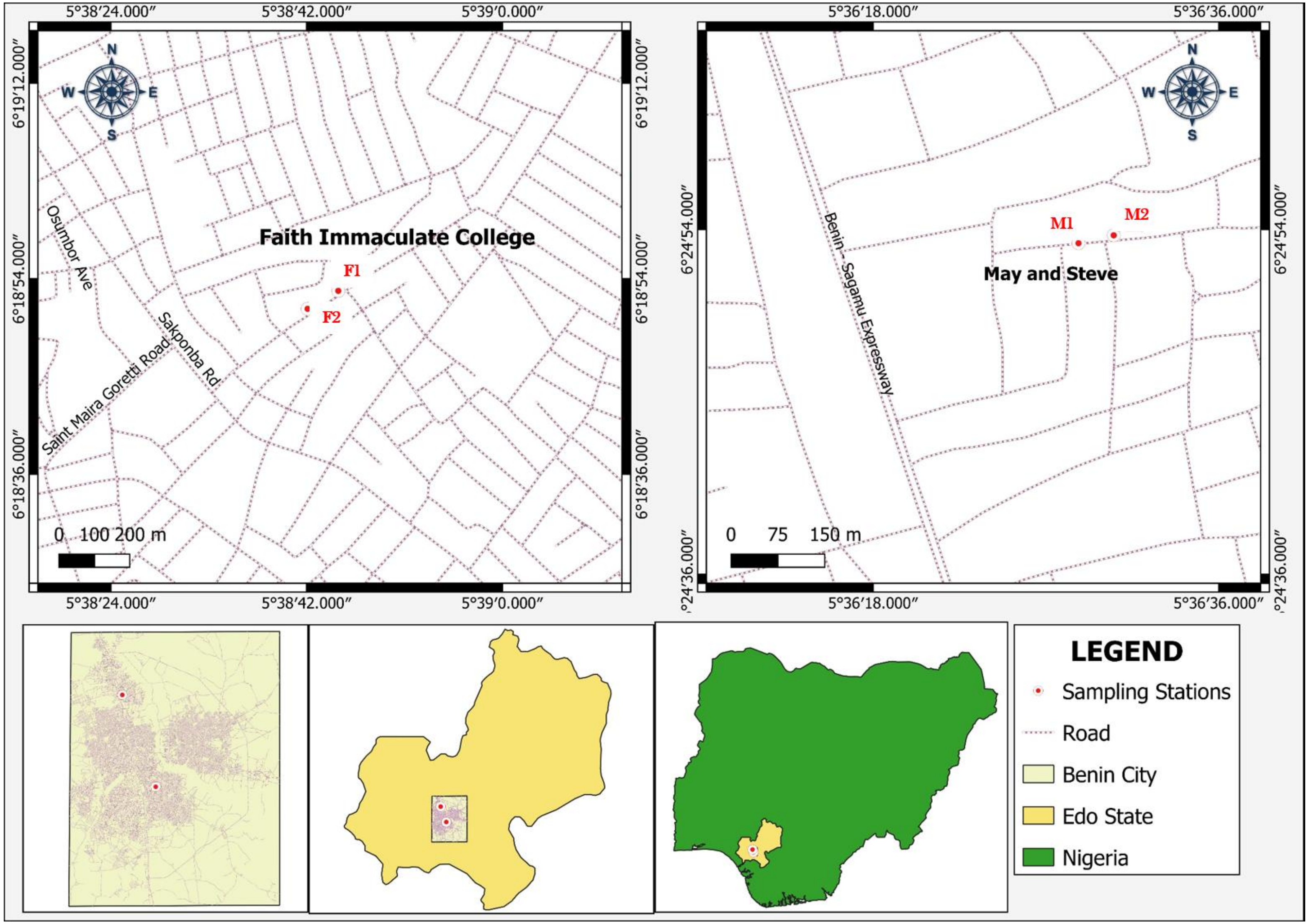

Figure 3.1: A map of the study area showing the sampling locations

3.3 PROCEDURES FOR ANALYSIS

3.3.1 Physicochemical analysis of water samples

3.3.1.1 pH

The pH of the water samples were analysed according to APHA (2005). Twenty (20) ml of each was poured into separate beakers. A pH meter, Hanna model, which had been properly calibrated, was then inserted into each beaker and the pH reading was recorded. Each measurement was done in duplicate and the mean value taken.

3.3.1.2 Nitrate

Ultraviolet visible spectrophotometry method was employed in the quantification of nitrate in the samples (APHA, 2005). A pipette was used to measure ten (10) ml of the sample into a 50ml flask. Two (2) ml of Brucine and then ten (10) ml of concentrated sulphuric acid were added to the sample. The solution was properly mixed and left to stand for about 10 minutes. The same treatments were administered to the standard solutions. Distilled water was used to make up to mark and analysis of the samples via spectrophotometry was carried out at 470nm.

3.3.1.3 Chloride

The determination of chloride in water samples was done using the argentometric titration method (APHA, 2005). One hundred millilitres (100ml) of the sample was measured into a conical flask and 1ml of potassium chromate ($K_2Cr_2O_7$) indicator was added. Titration of the following solution against $AgNO_3$ was carried out and the end-point was the formation of a pinkish-yellow colour. Also, titration with 0.3ml of a distilled water blank. The concentration of chloride in the samples was then calculated thus:

$$mg\ Cl^- = \frac{(A - B)\ \times N\ \times 3.545}{volume\ of\ sample}$$

Where, A = mL titration for the sample

B = mL titration for blank

N = normality of $AgNO_3$

3.3.1.4 Biochemical Oxygen Demand (BOD)

Preparation of dilution water was done by shaking vigorously and then adding 1ml each of calcium chloride, iron (III) chloride, magnesium sulphate and phosphate buffer. The dissolved oxygen concentration of the samples was determined before the BOD test. A 1M alkali solution was used to pre-treat the sample to bring the pH up to 7. The samples were diluted using the prepared dilution water and then pipetted into BOD bottles. The bottles were filled to the brim and stoppered. Using an incubator, the samples and blank were kept in the dark for 5 days at 20°C. After the incubation period was completed, the concentration of dissolved oxygen in the samples was determined. The BOD concentration was calculated as follows:

$$BOD\ (mg/L) = \left(DO_f - DO_i\right) \times \frac{Volume\ of\ the\ BOD\ bottle}{ml\ of\ sample\ used}$$

Where, DOf = dissolved oxygen after titration on the final day

DOi = dissolved oxygen on the initial day

3.3.2 Heavy Metal Analysis

Heavy metal concentrations in the samples were determined as follows: one litre of the sample was measured and concentrated to 50ml with the aid of a sandy oven heated to 80°C. After that, four (4) ml of concentrated sulphuric acid (Merck, 98%) was added and digestion was done for 3 minutes using the digesdahl apparatus. Ten (10) ml of hydrogen peroxide (Merck, 30%) was added to the mixture which was then heated. The sample was then cooled and filtered with a Whatman filter paper into a conical flask. The filtrate was made up to mark with distilled water. Flame atomic absorption spectrophotometry was used to determine the concentrations of the heavy metals present in the samples. Analysis was carried out in duplicate and the mean results were recorded in mg/L.

3.3.3 Microbiological analysis of water samples

3.3.3.1 Multiple tube technique

Presumptive test

Ten (10) ml of double strength MacConkey broth was measured into a test-tube and two sets of 5ml single strength of the same broth were measured into separate test-tubes. The test-tubes were then autoclaved at 121°C for 15 minutes. Upon completion of the sterilization, 10ml of the water sample was introduced into the tube with the double strength broth, while 1ml and 0.1ml of the sample, respectively, were introduced into the single strength broths. All tubes were incubated for 24 - 48 hours at 37°C, after which all tubes which showed evidence of acid production (colour change to yellow) were regarded as positive. The most probable number (MPN) per 100ml was recorded as against the positive tubes in the samples.

Confirmed Test

Brilliant green lactose bile (BGLB) broth was first sterilised for 15 minutes in an autoclave at 121°C. The presumptive tubes which showed positive results were gently shaken. A loopful of the the cultured microbes was transferred into the fermentation tubes containing the BGLB. The growth of gram-positive bacteria is inhibited by the brilliant green dye present in BGLB. The test-tubes were then incubated for 48 hours at 35°C. The test tubes were then observed and the production of gases in those of the BGLB medium indicated the presence of coliform bacteria.

Completed Test

A loopful of the culture form the confirmed tubes with positive results was taken and streaked unto the agar slants. These were then incubated for 24 - 48 hours at 35ºC.

3.3.3.2 Enumeration and isolation of total heterotrophic bacteria

The spread plate method was used in the enumeration and isolation of total heterotrophic bacteria. Molten nutrient agar and potato dextrose agar were poured into separate sterile petri dishes and then allowed to solidify. Into these petri dishes, 1ml of the samples were pipetted and then incubated for 24 hours at 37°C. All potato dextrose agar plates were incubated for 3 - 5 days at 25°C. Upon the completion of the incubation period, all emergent microbial colonies were counted and recorded. Each colony was then sub-cultured onto a freshly prepared agar plate by streaking. Gram staining and further biochemical tests were carried out using this purified culture (APHA, 2005).

3.3.3.3 Biochemical tests for the identification of the bacterial isolates

a. Gram-staining

Gram staining was done as described by Cheeseborough (2005). A smear of the bacteria isolates was applied on a microscope slide which was then air-dried and fixed by passing through a flame. Five (5) drops of Hucker's crystal violet was added to the culture and allowed to stand for one minute. Excess of the solution was washed off and 5 drops of iodine was added to the culture then allowed to stand for 30 seconds. Deecolorisation of the bacteria was done next using acetone-alcohol solution. Then 5 drops of Safranine O. was added to the isolate and allowed to stand for one minute after which water was used to wash of excesses. The slide was then observed under a microscope at 400x.

b. Oxidase test

The oxidase test was carried out according to Cheeseborough (2005). This test is used to differentiate *Pseudomonas* from other gram-negative rod bacteria. Oxidase test was carried out to identify bacteria species that will produce cytochtome oxidase enzyme. *Staphylococcus aureus* and *Escherichia coli* which are gram positive and gram negative respectively were employed as control. A piece of filter paper using sterilizes wire loop 2-3 drops of freshly prepared oxidase reagent (1% aqueous tetramethyl-3-phenyl nediamine dichloride) was added. A positive oxidase test is indicated by purple colouration within 10 seconds.

c. Urease test.

Urease was done as described by Cheeseborough (2005). This test is used to identify organisms which can produce the enzyme urease which catalyses the breakdown of urea to produce ammonia. The test is usually used to differentiate organisms like *Proteus mirabilis* from other non-urease positive organism. A sterilized medium was dispensed into test tubes aseptically and the test bacteria isolated were inoculated into the medium and incubated at 37^{o}C for 24 hours. A change in colour from yellow to red-pink confirmed the presence of urease.

d. Indole production test

The indole production test was carried out according to Cheeseborough (2005). This test is used in the identification of isolates which have the ability to split indole from tryptophan present in peptone water. The best is usually used in differentiating gram-negative bacilli especially those of enterobacteriaceae. Five (5) grams of peptone broth was dissolved in 1litre of distilled water. The medium was then sterilized by autoclaving at 121^{o}C for 15 minutes. Four (4) ml of the medium was dispensed into sterile test tube and each of the bacteria isolates was inoculated into the peptone broth. The inoculated media was incubated 37^oC for 24 hours after which few drops of KOVAC reagent was added. KOVAC reagents consist of 150ml of amylalcohol, 10g dimethylamino benzaldehyde and 150ml of concentrated hydrochloric acid. Positive test was indicated by the red colouration that occurs immediately at the upper part of the test tube.

e. Citrate utilization test

The citrate utilisation test was carried out as described in Cheeseborough (2005). This test is used in identification of isolated which are capable of utilizing citrate as the sole source of carbon for metabolism. The medium used for this test is Simon's citrate agar. In the preparation, 22g of Simon's citrate agar was dissolved in litre of distilled water and sterilized by autoclaving at 121^oC for 15 minutes. The medium is dispensed into test tubes and the test organism was inoculated by stabling the medium on the tubes using sterile straight inoculation wire containing culture. The tubes were incubated at 37^oC for about 24 hours. Positive result is indicated by a change in colour from green to bright blue colouration.

f. Catalase test

The catalase test was carried out according to Cheeseborough (2005). This test is done to detect the presence or absence of catalase enzyme. The catalase enzyme catalyses the breakdowns of hydrogen peroxide to release free oxygen gas and the formation of water. A few drops of freshly prepared 3% hydrogen peroxide were added onto the bacterial isolates smeared on a slide. The production of gas bubble indicated catalase enzyme positive.

g. Sugar fermentation and production of gases

The tests for sugar fermentation and the production of gases were carried out according to Cheeseborough (2005). Triple sugar iron agar (TSI) was prepared following manufacturer's instruction and the prepared media was placed in a test tube and kept in a slant position for it to solidify. The slant and butt of the medium was inoculated with the test bacterium using a sterile loop and it was incubated for 18-24 hr. The results were read on the basis of acid or alkaline production in the slant or butt region of the tube and gas production was confirmed by the presentence of crack or air bubbles in the slant or but region. More so, production of hydrogen sulphide was confirmed by the blackening of the medium. A prepared laboratory chart was used for result interpretation in line with microbiological standard protocol as well as other biochemical tests carried out on the isolates to confirm or ascertain their identity.

3.3.3.4 Antibiotic susceptibility test

Antibiotic susceptibility testing was done following methods described in APHA (2005). The antibiotic susceptibility test was carried out as follows: 37.5 grams of Mueller Hinton agar was weighed, dissolved in distilled water and sterilized at 121°C for 15 minutes. Upon cooling, the medium was poured in petri dishes. All tested bacterial isolates were streaked on the agar plates and the antibiotic discs were placed on the agar plates using sterile forceps. All the plates were then incubated for 24 hours at 37°C. After that, all the zones of inhibition were measured using a graduated ruler and recorded in millimetres.

3.3.3.5 Enumeration, isolation and identification of total fungi

One (1) ml of the sample was plated onto a Sabouraud Dextrose Agar (SDA) plate and incubated at 25 - 27°C for 3 to 5 days. The spores which grew were then subcultured on fresh SDA plates and preserved in agar slants. Primary identification of the isolates was done by their shapes and colours. This was after they were stained with lactophenol cotton blue and examined under x40 lens that showed the hyphae structures and spore arrangements.

3.4 ADMINISTRATION OF QUESTIONNAIRES

Information regarding water, sanitation and hygiene practices in the selected schools was collected using a questionnaire designed. A total of one hundred (100) questionnaires were distributed with fifty (50) to each school. However, of this number, only forty-eight (48) and forty-six (46) questionnaires were returned from Faith Immaculate Academy and May and Steve College, respectively. Information obtained through the questionnaires included respondent data, sources and availability of water, sanitation facilities and hand hygiene practice were analysed accordingly (See Appendix 1).

Plate 3.1: Distribution of questionnaires

Photo credit: Onome Ogba

Plate 3.2: Waste collection point at May and Steve Academy

Photo credit: Onome Ogba

Plate 3.3: Waste dump at Faith Immaculate College

Photo credit: Onome Ogba

3.5 DATA ANALYSIS

The calculation and presentation of data was done using Microsoft Office Excel 2016 sheets. Statistical analysis of the data was done with the aid of IBM SPSS version 20.

CHAPTER FOUR

RESULTS

The results obtained for the physicochemical analysis of the water samples in this study are shown in Table 4.1. The pH values of water ranged from 6.9 (F1) - 7.6 (M1). The minimum concentration of chloride in the sample was 14.20mg/l (F2) and the maximum was 28.4mg/l (M1). Nitrite concentrations was least in M1 (0.894mg/l) and the highest value was 1.614 recorded in F1 and M2. BOD concentrations ranged from 0.35mg/l (M1) to 1.15mg/l (F2).

Table 4.2 shows the microbial properties of the water samples collected from the schools during this study. The total heterotrophic bacterial count ranged from 3.5 x 10cfu/ml (M1) to 8.0 x 10 cfu/ml (F1 and M2). The total coliform count in the samples was least in F2 (4 MPN/100ml) and highest in F1 (17 MPN/100ml). In the case of total fungi, the count ranged between 2.0 x 10 cfu/ml (F1 and M1) to 5.0 x 10 cfu/ml (F2).

Table 4.3 shows the cultural, morphological and biochemical characteristics of the bacteria isolated from the water samples. The bacterial isolates were *Escherichia coli, Klebsiella* sp., *Staphylococcus aureus* and *Bacillus* sp. The antimicrobial susceptibility pattern of the isolates shown in table 4.4 revealed that all isolates were resistant to ciprofloxacin and metronidazole. Also, all isolates were susceptible to ciprofloxacin. Findings show that only *Bacillus* sp. was susceptible to tetracycline. The cultural and morphological characteristics of the fungal isolates from this study are shown in table 4.5. The fungal isolates are *Aspergillus niger, A. flavus, Mucor* sp. and *Penicillium citrinum.*

The demographic data of respondents to the questionnaires are shown in table 4.6. In Faith Immaculate College, the percentage of male and female respondents was equal to 50% each. Only 4% of the respondents were teachers, while the other 96% were students. Respondents in the age ranged of 17 - 18, 21 - 24 and 25 - 30 were only 2% each of the total respondents, however, those aged between 14 - 16 were the most frequent at 54%. None of the respondents received vocational education, and 96% of them received secondary education. All the respondents (100%) had a 'single' marital status. For May and Steve, the female respondents (54%) were more than the male respondents (46%). The teachers made up 10% of the respondents while students made up the other 96%. In terms of age, there were no respondents between the ages of 21 and 24, however, those between the ages of 14 - 16 were the most numerous (62%). Only 4% of the respondents received vocational education while 86% received secondary education. All respondents (100%) in the school were single.

In Faith Immaculate, the least used water source was the protected well (2%) and the most used was the borehole (72%). Only 4% of respondents reported that the water source was over 500m away from the premises, however, 54% reported that it was within 5000m of the school premises. Concerning the availability of water from the water source, the majority of respondents responded affirmative (84%). In May and Steve, 64% of respondents obtained water from a borehole, while only 2% got water from a protected well. Forty (40%) of respondents reported that the main water source was off the school premises but within 0, while 60% reported that the main water source was on the premises. On the availability of water at the main source, the affirmative responses on water availability at the main source were 78%.

The information collected on the core sanitation questions is summarised in table 4.8. In Faith Immaculate, the number of toilets available were reported to be 1 - 3 (100%). The least used type of toilet was the flush-to-pit system (32%), while the flush-to-sewer system was most commonly used (68%). Majority of the respondents indicated that the toilets for males and females were not separate (58%). Also, majority of respondents (66%) reported the absence of facilities to maintain menstrual hygiene. In May and Steve, 30% of respondents indicated the availability of more than 10 toilets in the school, however, 70% reported 1 - 3 toilets. The least used type of toilet was the flush-to-open-air system (4%), while the flush-to-sewer system was most commonly used (82%). Toilets were reported to be separated from male and female (94%). And, according to 64% of the respondents, facilities for menstrual hygiene were available.

The summary of results regarding the status of hand hygiene at Faith Immaculate and May and Steve schools are presented in Table 4.9. In the case of Faith Immaculate market, 48% of respondents reported that soap and water were available on the premises with 20% reporting their absence. Soap and water at toilets was reported to be available and within 5m of the toilets (76%). Ninety (90%) of respondents reported that staff were employed to clean the toilets. The practice of waste separation was reported to be carried out by 46% while 36% reported that it was not done. The practice of collection and open burning of waste was reported by78% of respondents, while collection of waste and burning in a central closure was reported by only 24% of respondents. The government waste management board was reported to collect and evaluate waste in the school by only 16% of respondents, and collection of waste by scavengers was reported by only 6% of respondents. In the case of May and Steve, 54% of respondents reported that soap and water were available on the premises with only 4% reporting their absence. Soap and water at toilets was reported to be available and within 5m of the toilets by 80% of the respondents. Eighty-two percent (82%) of respondents reported that staff were employed to clean the toilets. The practice of waste separation was reported to be carried out by 72% while 2% reported that it was not done. The practice of collection and open burning of waste was reported by 62% of respondents, while collection of waste and burning in a central closure was reported by 52% of respondents. The government waste management board was reported to collect and evaluate waste in the school by 60% of respondents, and collection of waste by scavengers was reported by 32% of respondents.

Table 4.1 Physicochemical and heavy metal content of water samples

	F1	F2	M1	M2	WHO
Ph	6.9	7.1	7.6	7.4	6.5-8.5
Chloride (mg/L)	21.30	14.20	28.4	17.75	250
Nitrite (mg/L)	1.614	1.460	0.894	1.614	3
BOD (mg/L)	0.40	1.15	0.35	0.49	4

Table 4.2: Total heterotrophic bacteria, total coliform and total fungal counts of water samples

Sample	Microbial Counts		
	THB (x10cfu/ml)	TCC (MPN/100ml)	TF (x10cfu/ml)
F1	8.0	17	2.0
F2	5.5	4	5.0
M1	3.5	12	2.0
M2	8.0	7	4.5

Total Heterotrophic Bacteria counts (THB), Total Coliform Counts (TCC) Total Fungi counts (TF)

Table 4.3: Cultural, morphological and biochemical characteristics of bacterial isolates

	1	2	3	4
		Cultural characteristics		
Shape	Circular	Circular	Circular	Circular
Elevation	Convex	Convex	Convex	Convex
Margin	Entire	Entire	Entire	Entire
Size	Small	Small	Small	Small
		Morphological characteristics		
KOH	+	+	-	-
Gram stain	-	-	+	+
Cell morphology	Rod	Rod	Cocci	Rod
Cell arrangement	Single	Single	Clusters	Single
		Biochemical characteristics		
Catalase	+	+	+	+
Coagulase	-	-	+	-
Indole	+	-	-	-
Oxidase	-	-	-	-
Citrate	-	+	+	+
Urease	-	+	+	-
H_2S	-	-	-	-
Glucose	+	+	+	+
Lactose	+	+	+	-
Sucrose	-	+	+	+
Identity	*E. coli*	*Klebsiella* sp	*S. aureus*	*Bacillus* sp.

Table 4.4: Antimicrobial susceptibility pattern of the bacterial isolates

ISOLATES	CS	CIP	GEN	E	TE	M	CD	AG
E.coli	0(R)	17(S)	12(I)	0(R)	0(R)	0(R)	9(R)	12(I)
Staphylococcus sp	0(R)	14(S)	15(S)	8(R)	0(R)	7(R)	11(I)	14(S)
Bacillus sp	0(R)	18(S)	15(S)	10(I)	14(S)	7(R)	0(R)	9(R)
Klebsiella sp	7(R)	22(S)	17(S)	10(I)	8(R)	0(R)	10(R)	15(S)

KEY

- R: RESISTANCE
- S: SUSCEPTIBLE
- CS: COLISTIN
- CIP: CIPROFLOXACIN
- GEN: GENTAMICIN
- E: ERYTHROMYCIN
- TE: TETRACYCLIN
- M: METRONIDAZOLE
- CD: CLINDAMYCIN
- AG: AUGMENTIN

Table 4.5: Cultural and morphological characteristics of fungal isolates

	1	2	3	4
Cultural characteristics of fungi isolates	Black fluffy colony with reverse side yellow	Cotton candy texture, white with pale yellowish brown reverse colour	Velvety white to gray-orange, reverse is white to pale yellow	Greenish-yellow colony with reverse side yellow
Type of hyphae	Septate	Septate	Septate	Septate
Colour of spore	Brown	White	Greyish	Brown
Type of spore	Conidiospore	Conidiospore	Conidiospore	Conidiospore
Possible isolate	*Aspergillus niger*	*Mucor* sp.	*Penicillium citrinum*	*Aspergillus flavus*

Table 4.6: Demographic data of respondents to the questionnaires

Category	Options	Frequency (%)	
		Faith Immaculate	May and Steve
Gender	Female	25 (50)	27 (54)
	Male	25 (50)	23 (46)
Position	Teacher	2 (4)	5 (10)
	Student	48 (96)	45 (90)
Age at last birthday	11 - 13	20 (40)	13 (26)
	14 - 16	27 (54)	31 (62)
	17 - 18	1 (2)	2 (4)
	21 - 24	1 (2)	-
	25 - 30	1 (2)	4 (8)
Level of Education	Vocational	-	2 (4)
	Secondary	48 (96)	43 (86)
	Higher	2 (4)	5 (10)
Marital status	Single	50 (100)	50 (100)

Table 4.7: Data on core water questions

Category	Options	Frequency (%)	
		Faith Immaculate	May and Steve
Main water source	Piped	6 (12)	14 (28)
	Borehole	36 (72)	32 (64)
	Unprotected Well	4 (8)	3 (6)
	Protected Well	1 (2)	1 (2)
	None	3 (6)	-
Location of water source	On premises	21 (42)	30 (60)
	Off premises <500m	27 (54)	20 (40)
	Off premises >500m	2 (4)	-
Water from main source is available	Yes	42 (84)	39 (78)
	No	8 (16)	11 (22)

Table 4.8: Data on core sanitation questions

Category	Options	Frequency (%)	
		Faith Immaculate	May and Steve
Number of toilets in school	1 - 3	50 (100)	35 (70)
	10 and greater	-	15 (30)
Type of toilet	Flush to sewer	34 (68)	41 (82)
	Flush to pit	16 (32)	7 (14)
	Flush to open air	-	2 (4)
Toilet separate for male and female	Yes	21 (42)	47 (94)
	No	29 (58)	3 (6)
Female toilet with facilities to manage menstrual hygiene	Yes	17 (34)	32 (64)
	No	33 (66)	18 (36)

Table 4.9: Data on core hand hygiene questions and waste management

Category	Options	Frequency (%)	
		Faith Immaculate	May and Steve
Soap and water or hand rub available on premises	Yes	24 (48)	27 (54)
	Partially	16 (32)	21 (42)
	No	10 (20)	2 (4)
Soap and water currently available at toilets	Yes <5m	38 (76)	40 (80)
	Yes >5m	4 (8)	5 (10)
	No	8 (16)	5 (10)
Staff employed to clean toilets	Yes	45 (90)	41 (82)
	No	5 (10)	9 (18)
Waste separated into bins	Yes	23 (46)	36 (72)
	Somewhat	9 (18)	13 (26)
	No	18 (36)	1 (2)
Waste centrally collected and openly burnt	Yes	39 (78)	31 (62)
	No	11 (22)	19 (38)
Waste centrally collected and burnt in closure	Yes	12 (24)	26 (52)
	No	38 (76)	24 (48)
Waste collected and evacuated by Government WM Board	Yes	8 (16)	30 (60)
	No	42 (84)	20 (40)
Waste collected and evacuated by scavengers	Yes	3 (6)	16 (32)
	No	47 (94)	34 (68)

CHAPTER FIVE

DISCUSSION

5.1 Discussion

Children spend a great deal of daytime for a large portion of the year in school. The availability of water, sanitation and hygiene facilities in these schools is key to protecting the health of these children. When these facilities are available, there is lesser chance of disease outbreaks and could translate to better school attendance and improved academic performances (He *et al.,* 2018). This study was carried out to assess the WASH status of May and Steve Academy and Faith Immaculate College in Egor Local Government Area of Edo State.

The results obtained for the physicochemical analysis of water are shown in Table 4.1. It is seen that, the pH values of the water samples from both schools were between 6.9 - 7.6 which falls within the range of pH values recommended by the World Health Organisation (WHO) for drinking water i.e. 6.5 - 8.5 (WHO, 2017). The recommended limit for chloride in drinking water is 250mg/l and the values obtained in this study for chloride are well below this limit. Nitrite concentrations in this samples ranged from 0.894 - 1.614mg/l which were below the recommended WHO limit of 3mg/l in water (WHO, 2017). Biochemical Oxygen Demand (BOD) concentrations in the samples ranged from 0.35 - 1.15mg/l. This range of values was less than the maximum permissible limit of 4mg/l for BOD in water as recommended by the WHO (2017). These parameters showed the absence of physicochemical water contamination in the study area. Similar results for physicochemical parameters in water have been recorded in previous studies (Airaodion *et al.,* 2019; Solana *et al.,* 2020).

The results from the microbiological analysis of the samples collected from the study area are shown in Table 4.2. The total heterotrophic bacteria counts obtained ranged from 3.5 x 10 - 8.0 x 10cfu/ml. The Centres for Disease Control recommends that total heterotrophic bacteria in water should not exceed 500cfu/ml (CDC, 2003) and in this study, the limit was not exceeded. Regarding total coliform counts, it is recommended that it does not exceed 1 bacteria/100ml by CDC (2003), however, this limits was exceeded in all the samples collected and indicated faecal contamination of the water in the study area. Faecal contamination of water threatens public health as the organisms involved are capable of causing a wide range of diseases (Pruss *et al.,* 2002). The bacterial isolates from this study included *Escherichia coli, Klebsiella* sp., *Staphylococcus aureus* and *Bacillus* sp. The antimicrobial susceptibility pattern (Table 4.4) showed that all isolates were resistant to colistin and metronidazole, and were all susceptible to ciprofloxacin, indicating that ciprofloxacin could be used in the treatment of these organisms as has been reported in Bantawa *et al.* (2019). Total fungal counts ranged from 2.0 x 10 - 5.0 x 10cfu/ml in the samples and these values were within limits as stated in Oliveira *et al.* (2016). The fungal isolates are *Aspergillus niger, A. flavus, Mucor* sp. and *Penicillium citrinum.* These organisms were also isolated in a study by Oliveira *et al.* (2016).

Demographic data gathered from the respondents to the questionnaires are shown in Table 4.6. It shows that the respondents gender distribution was equal (50% each) for Faith Immaculate, while for May and Steve Academy, the female respondents (54%) were slightly more than the males. In both schools, the majority of the respondents were students with ages in the range of 14 - 16. The level of educations for majority of the respondents was mainly secondary with 96% in Faith Immaculate and 86% in May and Steve Academy. All respondents (100%) from both schools fell under the ‘single’ marital status category.

As shown in Table 4.7, the primary source of water for WASH in both schools were boreholes at 72% and 64% for Faith Immaculate and May and Steve Academy, respectively. Concerning the location of the water source, majority of the respondents from Faith Immaculate (54%) report that it was within 500m of the premises, while 60% of those from May and Steve Academy reported that the water source was on the premises. On the availability of water at the main source, the response was affirmative with 84% and 78% for Faith Immaculate and May and Steve, respectively. These finding are in line with the provisions for water availability according to the United Nations General Assembly (Bennet *et al.,* 2018).

The summary of data gathered on the core sanitation questions is shown on Table 4.8. all respondents (100%) in Faith Immaculate and 70% of those at May and Steve Academy reported that toilets available in the schools were between 1 - 3, with the flush-to-sewer type being the most prevalent at 68% and 82%, respectively. A higher percentage (58%) of Faith Immaculate respondents reported that the toilets for male and female were not separated, but for May and Steve Academy, 94% of respondents reported that they were separated. Also, in Faith Immaculate, the question on availability of facilities for the management of menstrual hygiene received generally negative responses (66%), but in May and Steve Academy, 64% of respondents reported the availability of these facilities.

Information on the core hand hygiene and waste management status of the schools assessed is shown on Table 4.9. The higher percentage of respondents from the schools indicated that there was soap and water/hand-rub for hand hygiene available on the school premises. However, the percentages were lower than those for the availability of soap and water at the toilets which were generally positive as follows: 76% for Faith Immaculate and 80% for May and Steve Academy. Majority of the respondents (90% and 82%, respectively) report that there were staff employed for the purpose of maintaining the sanitary conditions of the toilets.

On the separation of waste generated, there were mixed responses for Faith Immaculate, however, majority of the respondents (72%) of May and Steve reported that waste was separated into bins. Open burning of waste was found to be a common practice in the schools at 78% for Faith Immaculate and 62% for May and Steve. Burning of waste within an enclosure was not commonly done in Faith Immaculate (76%) although, in May and Steve Academy, it was a common practice (52%). The collection of waste by the Edo State Waste Management Board was not commonly carried out in Faith Immaculate (84%), while 60% of the respondents from May and Steve Academy reported that the Board carried out waste collection and excavation in the school. The collection and excavation of waste by scavengers was not a common practice in either Faith Immaculate (94%) or May and Steve Academy (68%). Similar results have been recorded in previous studies (Orimoloye *et al.,* 2015).

5.2 Conclusion

The availability of water, sanitation and hygiene is a key facet of public health protection. In this present study, the quality of water and the status of WASH in Faith Immaculate College and May and Steve Academy, Benin City showed that the physicochemical properties of the water collected from the study area were all within the recommended limits of the WHO. However, coliform contamination was detected in all the water samples indicating that consumption of these waters could be harmful to health. The rating of the WASH status of the schools based on the responses of the respondents was generally positive especially for May and Steve Academy. It is recommended that the water in both schools be subjected to treatment for the removal of coliform bacteria, and the government make more effort in the areas of waste management especially for Faith Immaculate College while adjustments should be made in the toilet facilities for Faith Immaculate College.

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APPENDIX 1

WATER, SANITATION AND HYGIENE ASSESSMENT TOOL

Instruction: Please tick the most appropriate response for all the questions

Name of LGA ________________________________

Name of school _______________________________

Date ____

DEMOGRAPHIC DATA

Q1	Sex of respondent	Female ______________ Male ________________
Q2	Respondent official status	Principal _____________ Teacher ______________ Security ______________ Student ______________
Q3	How old were you at your last birthday	11 - 13 __________ 14 - 16 __________ 17 - 18 __________ 18 - 20 __________ 21 - 24 __________ 25 - 30 __________ 31 - 40 __________ 41 - 50 __________ 50 _______________
Q4	Level of education	No education _______________ Vocational __________________ Qur'anic only _______________ Primary ____________________ Secondary __________________ Higher _____________________
Q5	Marital Status	Married ____________________

		Co-habiting ________________ Single _____________________ Divorced ___________________ Separated __________________ Widow/Widower ____________

CORE WATER QUESTIONS

1. Main water source (select one)

   Piped [ ] Borehole [ ] Protected dug well [ ] Unprotected dug well [ ] Protected spring [ ] Unprotected spring [ ] Surface water (River/Lake/Canal) [ ] No water source [ ] Other _________
2. Main water source is on premises?

   Yes [ ] Off premises but less than 500m [ ] More than 500m [ ]
3. Water from the main source is currently available

   Yes [ ] No [ ]

CORE SANITATION QUESTIONS

4. Number of usable (available, functional, private) toilets within the school _________
5. Type of toilet/latrine (select the most common)

   Flush/Pour-flush to sewer [ ] Flush/Pour-flush to tank/pit [ ] Flush/Pour-flush to open [ ] Pit latrine with slab/covered [ ] pit latrine without slab/open [ ] Bucket [ ] Hanging toilet/Latrine [ ] None [ ]
6. Toilet separated for male and female

   Yes [ ] No [ ]
7. Female toilet has facilities to manage menstrual hygiene needs (covered bin and/or water and soap)

   Yes [ ] No [ ]

CORE HAND HYGIENE QUESTIONS

8. Soap and water (or alcohol-based hand rub) currently available in premises

Yes [ ] Partially (lacking materials) [ ] No [ ]

9. Soap and water currently available at toilets

   Yes, within 5m of toilet [ ] Yes, more than 5m from toilet [ ] No soap or water [ ]

10. Are staff employed to clean the toilets

    Yes [ ] No [ ]

11. General wastes are safely separated into three bins

    Yes [ ] Somewhat (bins full, include other waste or only1 or 2 available) [ ] No [ ]

12. Waste are centrally collected and openly burnt

    Yes [ ] No [ ]

13. Waste are centrally collected and burnt in enclosure

    Yes [ ] No [ ]

14. Wastes are collected and evacuated by the Government waste management board

    Yes [ ] No [ ]

15. Wastes are collected and evaluated by scavengers (local boys)

    Yes [ ] No [ ]